

ENERGY REPORT

ENERGY ENGINEERING ANALYSIS PROGRAM

LIMITED ENERGY STUDY

**FORT HUNTER-LIGGETT, CALIFORNIA
1993**

VOLUME I

19971016 218

PREPARED FOR

**DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA**

PREPARED BY

**KELLER & GANNON
ENGINEERS • ARCHITECTS
1453 MISSION STREET, SAN FRANCISCO, CA 94013**

CONTRACT NO. DACA05-C-92-0155

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

DTIC QUALITY INSPECTED 2

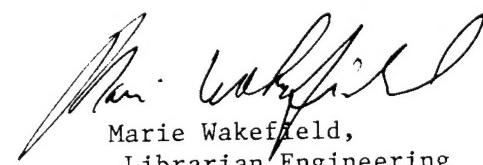


DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.
Distribution A. Approved for public release.



Marie Wakefield,
Librarian Engineering

Table of Contents

	<u>Page</u>
1.0 Executive Summary	
1.1 Introduction	1-1
1.2 Installation Profile	1-1
1.3 Present Energy Consumption	1-1
1.4 Energy Conservation Analysis	1-1
1.5 Energy and Cost Savings	1-3
2.0 Introduction	
2.1 Purpose	2-1
2.2 Scope	2-1
2.3 Methodology	2-1
3.0 Description of Installation	
3.1 Location, Size and Climate	3-1
3.2 Population and Building Summary	3-1
3.3 Description of Utility Systems	3-2
3.4 Future Changes Planned or Anticipated	3-2
3.5 Historical Energy Consumption and Demand	3-2
3.6 Review of Previous Energy Audit	3-3
4.0 Energy Conservation Plan	
4.1 Energy Balance	4-1
4.2 Projected Energy Consumption	4-1
4.3 Construction Cost Estimate Methodology	4-2
4.4 Life Cycle Cost Analysis Assumptions	4-2
4.5 Summary of Energy Conservation Opportunities Studied	4-5
4.6 Recommended Energy Conservation Projects	4-5
5.0 Feasibility of New Natural Gas Service	5-1
6.0 Feasibility of New Central Propane Plant	6-1

	<u>Page</u>
7.0 Base-Wide Metering Plan	
7.1 Present Metering Plan	7-1
7.2 Proposed Metering Plan	7-1
7.3 Energy and Cost Savings	7-4
8.0 Feasibility of Base-Wide FM Radio Energy Monitoring and Control System	
8.1 Potential Systems For Connection To EMCS By Program Function	8-1
8.2 Local Building Retrofits Included In EMCS Analysis	8-2
8.3 Description Of Potential EMCS	8-3
8.4 Life-Cycle Cost Analysis	8-3
9.0 Feasibility of Cogeneration	9-1
10.0 Alternative Implementation Methods	10-1
11.0 Impact of Changing to Environmentally Acceptable Refrigerants	11-1
Appendix A Scope of Work and Minutes of Project Meetings	
Appendix B Baseline Energy Use Calculations	
B-1 Methodology	B-1
B-2 Space Heating, Cooling, and Ventilation Energy Use	B-1
B-3 Domestic Hot Water Energy Use	B-3
B-4 Lighting Energy Consumption	B-3
B-5 Process Energy Usage	B-4
B-6 Estimated Energy Use Versus Recorded Energy Use	B-4
Appendix C Weather Data	
C-1 Development of Hourly Temperature Data for Fort Hunter Liggett	C-1
C-2 Daily Degree-Hour Schedules	C-2
Appendix D Backup Data: Building Energy Conservation Opportunity Analyses	
Appendix E Future Energy Consumption Calculations	
Appendix F Building Data Bases and Survey Forms	
Appendix G Energy Conservation Regulation and Engineering Technical Letters	

List of Figures

	<u>Section</u>
1.1 Projected Energy Consumption by End Use	1.0
3-1 Location Map	3.0
3-2 Headquarters -- Fort Hunter Liggett Electrical Usage	3.0
3-3 Headquarters -- Fort Hunter Liggett Electrical Demand	3.0
3-4 Cantonment Area -- Fort Hunter Liggett Heating Oil Usage	3.0
3-5 Old Housing -- Fort Hunter Liggett -- Electrical Usage	3.0
3-6 Well and Range -- Fort Hunter Liggett -- Electrical Usage	3.0
4-1 Baseline Energy Consumption By Use	4.0
4-2 Baseline Energy Consumption By Facility	4.0
4-3 Projected Energy Consumption By End Use	4.0
4-4 Projected Energy Consumption By Facility	4.0
C-1 Check of Synthesized Weather Data Against Records	Appendix C
C-2 Check of Synthesized Weather Data For January and July	Appendix C
C-3 Check of Synthesized Weather Data For February and August	Appendix C
C-4 Check of Synthesized Weather Data For March and September	Appendix C
C-5 Check of Synthesized Weather Data For April	Appendix C
C-6 Check of Synthesized Weather Data For October	Appendix C
C-7 Check of Synthesized Weather Data For May and November	Appendix C
C-8 Check of Synthesized Weather Data For June and December	Appendix C

List of Tables

	<u>Section</u>
1-1	Summary of ECO Evaluations
1-2	Summary of Analysis Results for Recommended ECOs
1-3	Summary of Analysis Results for ECOs Not Recommended
3-1	Exterior Lighting Inventory
3-2	Summary of Construction Projects
4-1	Baseline Energy Consumption by End Use
4-2	Baseline Energy Consumption by Facility Function
4-3	Future Energy Consumption by End Use
4-4	Future Energy Consumption by Facility Function
4-5	Percent Energy Savings by End Use
4-6	Percent Energy Savings by Facility Function
4-7	Summary of 1993 PG&E Rebate Programs
4-8	Summary of ECO Evaluations
4-9	Summary of Analysis Results for Recommended ECOs
4-10	Summary of Analysis Results for ECOs Not Recommended
5-1	Economic Evaluation of the Conversion of Existing Fuel Types to Natural Gas ..
5-2	Detailed Cost Estimate For New Natural Gas Service
6-1	Detailed Cost Estimate For New Central Propane Facility
7-1	Metering Plan Unit Cost Estimates
9-1	Detailed Cost Estimate For Propane Cogeneration Plant on Site at Fort Hunter Liggett
11-1	Refrigerant Production Table
11-2	Short-Term and Long-Term Refrigerant Solutions
B-1	Summary Baseline Energy Use
B-2	Summary Baseline HVAC and DHW Energy Use
B-3	Summary Baseline Lighting and Process Energy Use
B-4	Baseline HVAC Energy Use Calculation Results
B-5	Existing Heating Equipment Efficiencies Serving EEAP Buildings
B-6	Domestic Water Consumption Rate Data
	Appendix B

	<u>Section</u>
B-7 Existing Domestic Hot Water Heating Equipment Efficiencies Serving EEAP Buildings	Appendix B
B-8 Baseline Domestic Hot Water Energy Use Calculations	Appendix B
B-9 Building Baseline Lighting Energy Use Summary	Appendix B
B-10 Process Electric Energy Use Summary	Appendix B
B-11 Estimated Energy Use Versus Recorded Energy Use	Appendix B
B-12 Lighting Energy Use Calculation Methodology	Appendix B
B-13 Process Electric Energy Use Summary	Appendix B
C-1 Design Weather Data From TM 5-785	Appendix C
C-2 Hourly Heating Degree-Hour Data For Fort Hunter Liggett (65°F)	Appendix C
C-3 Hourly Cooling Degree-Hour Data For Fort Hunter Liggett (65°F)	Appendix C
C-4 Hourly Heating Degree-Hour Data For Fort Hunter Liggett (70°F)	Appendix C
C-5 Hourly Cooling Degree-Hour Data For Fort Hunter Liggett (70°F)	Appendix C
E-1 Summary Future Energy Use	Appendix E
E-2 Summary Future HVAC and DHW Energy Use	Appendix E
E-3 Summary Future Lighting and Process Energy Use	Appendix E
F-1 EEAP Building (Real Property List Records)	Appendix F
F-2 Summary of Heating Equipment and Efficiencies Serving EEAP Buildings	Appendix F
F-3 Summary of Cooling Equipment Serving EEAP Buildings Space and Process Cooling Requirements	Appendix F
F-4 Existing Domestic Hot Water System Summary	Appendix F
F-5 Building Lighting System Summary	Appendix F
F-6 Lighting Fixture Data Summary	Appendix F

1.0 Executive Summary

1.1 Introduction

This report summarizes all work or the Limited Energy Study, Energy Engineering Analysis Program (EEAP), fort Hunter Liggett, California, authorized under Contract Number DACA 05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, California.

The purpose of this study is to develop projects and actions that will reduce facilities energy consumption and operating costs at Fort Hunter Liggett. Implementation of these projects will contribute to achieving the goal of the Army Facilities Energy Plan of a reduction in energy consumption per square foot of building floor area of 20 percent by FY2000 from FY1985 baseline levels.

1.2 Installation Profile

There are 205 numbered structures at Fort Hunter Liggett, containing a total of 791,034 square feet of gross floor space. This Limited Energy Study evaluates 52 surveyed buildings with results extended to an additional 44 identical or similar buildings. Together, these buildings contain a total of 632,386 gross square feet and account for approximately 93 percent of overall energy usage.

1.3 Present Energy Consumption

Total energy consumption at Fort Hunter Liggett in FY1992 of non-transportation energy sources was 79,728 million Btu. This figure includes electricity at 3,413 Btu per kWh, No. 2 fuel oil at 138,700 Btu per gallon and propane at 95,000 Btu per gallon.

A breakdown in FY1992 energy consumption and cost for all three sources is as follows:

Energy Source	Quantity	Million Btu's	Cost
Electricity	11,605,000 kWh	39,608	\$1,034,746
No. 2 Fuel Oil	136,058 gallons	18,871	\$97,845
Propane	223,700 gallons	21,249	\$174,724

1.4 Energy Conservation Analysis

A summary of all potential energy conservation opportunities (ECOs) investigated is presented in Table 1-1. This table includes a matrix of reasons for eliminating ECOs from further consideration. A summary of analysis results of recommended ECOs is

presented in Table 1-2, and a summary of analysis results of ECOs rejected is presented in Table 1-3.

1.4.1 ECIP Projects Developed

An ECIP project covering cantonment facility energy improvements was developed that includes the following retrofit measures:

- a. Install batt insulation in the ceilings of 9 buildings.
- b. Install programmable controllers in 9 buildings.
- c. Insulate hot water heating and cooling water piping in 12 buildings.
- d. Install 24-hour programmable thermostats in 28 buildings.
- e. Replace spare cooling equipment in 10 buildings with more efficient systems.
- f. Install automatic-draft damper controls on space heating equipment in 20 buildings.
- g. Convert dual-duct air handling system to variable air volume in 5 barracks buildings.
- h. Replace boilers with high-efficiency units in 7 buildings.
- i. Insulate domestic hot water piping in 6 buildings.
- j. Insulate 16 domestic hot water storage tanks in 13 buildings.
- k. Install self-metering lavatory faucets in 3 buildings and install lavatory and shower flow restrictors in 2 buildings.
- l. Install dishwasher heat recovery unit in Building 206.
- m. Install automatic-draft dampers on domestic hot water heaters in 3 buildings.
- n. Replace incandescent lighting fixtures with fluorescent fixtures in 9 buildings.
- o. Install automatic power factor correction equipment at utility metering point. Install power factor correction capacitors on 10 HP and larger motors in 6 buildings.

The following ECIP project data is from the life cycle cost analysis summary sheet:

Construction Cost (Including SIOH)	\$833,000
Annual Energy Savings	
Electricity	2,188 million Btu
No. 2 Fuel Oil	3,277 million Btu
Propane	4,242 million Btu
Annual Dollar Savings (Annualized)	\$142,191
Savings-to-Investment Ratio (SIR)	2.25
Simple Payback Period	5.9 years
Analysis Date	June 1993

1.4.2 Non-ECIP Projects Developed

It is recommended that Fort Hunter Liggett Directorate of Engineering and Housing program personnel to adjust the temperature setpoints on domestic hot water heating systems annually. A summary of the life cycle cost analysis supporting this recommendation follows:

Construction Cost (First Year Operations)	\$5,585
Annual Energy Savings	
Electricity	199 million Btu
No. 2 Fuel Oil	578 million Btu
Propane	430 million Btu
Annual Dollar Savings	\$4,891
Savings-to-Investment Ratio (SIR)	13.33
Simple Payback Period	1.1 years
Analysis Date	June 1993

1.5 Energy and Cost Savings

If all recommended ECOs are implemented, total energy savings of 11,500 million Btu and total annual cost savings of \$167,000 will result.

As shown in the pie chart in Figure 1-1, the potential savings represents 17.2 percent of the existing base-wide energy consumption.

PROJECTED ENERGY CONSUMPTION BY END USE

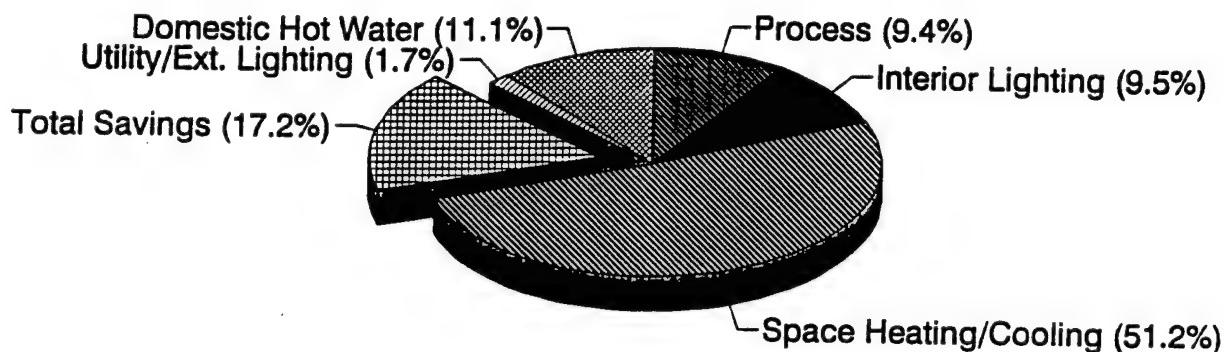


FIGURE 1-1

**TABLE 1-1
Summary of ECO Evaluations
Fort Hunter Liggett, California**

No.	Description of ECO	Recommended Project	SIR Less Than 1.0	DEH Maintenance	PG&E Project	N/A
Architectural						
A1	Caulk and Weatherstrip		✓			
A2	Install Double Glazing					✓
A3	Insulate Exterior Walls		✓			
A4	Insulate Ceilings and/or Roofs	✓				
A5	Install Solar Film		✓			
A6	Reduce Glass Area					✓
A7	Install Shading Devices		✓			
HVAC						
B1	Install Duty Cycling Controls	✓				
B2	Shade Condensers from Direct Sunlight		✓			
B3	Insulate Ductwork		✓			
B4	Replace Heating System Pipe Insulation	✓				
B5	Install Outside Air Temperature Reset		✓			
B6	Install Time Clocks and Programmable Thermostats	✓				
B7	Replace Inefficient Chillers	✓				
B9	Install Heat Recovery System		✓			
B10	Install Automatic Flue Dampers on Heating System Boilers	✓				
B11	Install Economizer Cycle		✓			
B12	Install Boiler Oxygen Trim Controls and Revise Controls		✓			
B13	Install Evaporative Precoolers		✓		✓	
B14	Install Multizone Controls		✓		✓	
B15	Convert Multizone HVAC System to Variable Air Volume	✓			✓	
B16	Automate Summer/Winter Switchover	Evaluated as part of ECO B6/B7		✓		
B17	Relocate Transformer	✓		Done May 93	✓	
B18	Add Zone Optimizer to Reheat Systems		✓		✓	
B19	Add Deadband Controls	Evaluated as part of ECO B6/B7		✓		
B20	Consolidate Food Storage				✓	✓

**TABLE 1-1
Summary of ECO Evaluations
Fort Hunter Liggett, California**

No.	Description of ECO	Recommended Project	SIR Less Than 1.0	DEH Maintenance	PG&E Project	N/A
B21	Replace Inefficient Boilers with Higher-Efficiency Boilers	✓				
Domestic Hot Water (DHW)						
C1	Reduce Hot Water Temperatures	✓				
C2	Replace Pipe Insulation DWH Systems	✓				
C3	Insulate Hot Water Storage Tanks	✓				
C4	Install Electrical Ignitors in Gas Hot Water Heaters					✓
C5	Install Aerators/Flow Restrictors in Lavatories and Showers	✓				
C6	Use Cold Water for Laundering					✓
C7	Replace Electric Booster for Garbage Can Washer	✓		Disconnected by DEH	✓	
C8	Recover Heat from Dining Facility Dishwashing	✓				
C9	Install Automatic Draft Damper Controls on DHW Heaters	✓				
Lighting and Electrical						
D1	Reduce Lighting Levels					✓
D2	Install Time Clocks on Exterior Lighting				✓	✓
D3	Retrofit Exterior Lighting with HPS Fixtures		✓		✓	
D4	Replace Incandescent Lighting with Fluorescent	✓			✓	
D5	Install Electronic Ballasts and T8 Lamps		✓			
D6	Revise Transformer Loading					✓
D7	Improve Voltage Regulation					✓
D8	Improve Power Factor	✓				
D9	Replace Motors with High Efficiency Units		✓	✓		
D10	Install FM Radio EMCS		✓			

Table 1-2
Summary of Analysis Results for Recommended ECO's

ECO No.	Description of ECO	Energy Savings:			Total Equiv. MBTU/Yr	\$ / Yr	Cost Savings LCC \$	Investment \$	SIR
		Fuel Oil MBTU/Yr	Propane MBTU/Yr	Electric MBTU/Yr					
C7	Replace Electric Booster for Garbage Can Washer (Implemented by DEH)	(144.0)		102.0	(42)	\$7,865	\$90,526	\$536	168.79
C1	Reduce Hot Water Temperatures (DEH O&M project)	430.0	578.0	199.2	1,207	\$4,891	\$74,457	\$5,585	13.33
B6/B7	Install Time Clocks & Night Set Back/Setup	2,460	3,399	1,252	7,111	\$53,286	\$715,760	\$66,368	10.79
B1	Install Load Shedding System (Local Controllers)			130.8 kW	130.8 kW	\$14,122	\$165,227	\$26,187	6.03
C5	Install Aerators/Flow Restrictors In Lavatories and Showers		2.0	13.0	15	\$250	\$2,964	\$501	5.91
C2	Replace Insulation on DHW Pipes and Fittings	48.0	15.0		63	\$357	\$4,968	\$856	5.81
C9	Install Automatic Draft Damper Controls	51.0	31.0		82	\$498	\$6,954	\$1,909	3.64
C8	Recover Heat From Dishwasher Hot Water	339.0			339	\$1,528	\$21,483	\$6,510	3.30
B17	Relocate Transformer (Implemented by DEH)			21.5	22	\$588	\$8,540	\$2,676	3.19
B10	Automatic Draft Damper Control on Space Heating Equipment	282.2	174.3		457	\$2,777	\$38,790	\$14,561	2.66
A4	Insulate Ceilings/Roofs	88.0	289.0	69.0	446	\$4,220	\$71,904	\$28,430	2.53
B4	Replace Insulation on Heating Piping and Fittings (See Note 1)	60.6	39.1	0.1	100	\$540	\$7,750	\$3,115	2.49

**EEAP, Limited Energy Study
Fort Hunter Liggett, California**

Revised July 1993

Table 1-2 (Cont.)
Summary of Analysis Results for Recommended ECO's

ECO No.	Description of ECO	Energy Savings:			Total Equiv. MBTU/Yr	Cost Savings \$ / Yr	Investment \$	SIR
		Fuel Oil MBTU/Yr	Propane MBTU/Yr	Electric MBTU/Yr				
D4	Replace Incandescent Lighting With Fluorescent			160.5	161	\$7,649	\$88,515	2.35
C3	Insulate Hot Water Storage Tanks	28.0	36.0	5.0	68	\$510	\$6,925	3.34
D8	Improve Power Factor			46.6	47	\$7,745	\$106,444	1.72
B15	Retrofit to Variable Air Volume			178.0	178	\$3,246	\$37,973	1.72
B8	Replace Inefficient Chillers (See Note 2)			353.7	354	\$49,554	\$597,123	1.47
B21	Replace Boiler			915.7	916	\$7,206	\$102,039	1.40
B18	Add Zone Optimizer to Reheat Systems			15.1	15	\$329	\$3,849	1.31
Totals for Recommended ECO's		3,643	5,478	2,416	11,537	\$167,161	\$2,152,191	2.71

Notes:

1. ECO B4 is evaluated also for use of removable insulation; standard insulation is recommended and is displayed above.
2. Annual cost savings includes annualized nonrecurring cost savings.

Table 1-3
Summary of Analysis Results for ECO's Not Recommended

ECO No.	Description of ECO	Energy Savings:				Total Equiv. MBTU/Yr	Cost Savings \$/Yr	LCC \$	Investment \$	SIR
		Fuel Oil MBTU/Yr	Propane MBTU/Yr	Electric MBTU/Yr						
B14	Install Multizone Controls	88.0	32.0	396.0		516	\$7,907	\$94,047	\$128,183	0.73
B11	Install Economizer Cycle for "Free" Cooling			323.4		323	\$6,407	\$74,959	\$107,227	0.70
D3	Retrofit Exterior Lighting With HPS Fixtures (unit screening analysis)			3.9	4		\$107	\$1,229	\$1,858	0.66
D10	Install FM Radio EMCS	2,460.0	3,399	1,841	7,700	\$86,136	\$1,102,103	\$2,329,435	\$2,329,435	0.47
A1	Caulk and Weatherstrip Doors and Windows	1,435.0	670.0	94.2	2,199	\$14,476	\$68,581	\$154,110	\$154,110	0.45
B3	Insulate Ductwork		5.4			5	\$42	\$593	\$1,337	0.44
D5	Install Electronic Ballasts and T8 Lamps (unit screening analysis)			0.1	0	\$4	\$40		\$94	0.43
B5	Install Outside Air Temperature Reset Controls	7.0			7	\$28	\$403		\$1,231	0.33
A5	Install Solar Film on Windows			355.0	355	\$7,753	\$34,812	\$117,382	\$117,382	0.30
B9	Install Heat Recovery System	58.0			58	\$289	\$3,980	\$16,247	\$16,247	0.24
B2	Shade Refrigerant Condensers From Direct Sunlight		279.0		279	\$2,386	\$29,480	\$187,624	\$187,624	0.16
A3	Insulate Exterior Walls	47.0	1.0	14.0	62	\$547	\$8,709	\$116,161	\$116,161	0.07

Table 1-3 (Cont.)
Summary of Analysis Results for ECO's Not Recommended

ECO No.	Description of ECO	Energy Savings:			Total Equiv. MBTU/Yr	\$ / Yr	Cost Savings LCC \$	Investment \$	SIR
		Fuel Oil	Propane	MBTU/Yr					
A7	Install Shading Devices for Windows			17.0	17	\$85	\$394	\$20,411	0.02
A2	Install Double Glazing								
A6	Reduce Glass Area								
C4	Install Electric Ignitors In Gas Hot Water Heaters								
C6	Use Cold Water for Laundering								
D1	Reduce Lighting Levels								
D2	Install Time Clocks on Exterior Lighting								
D6	Revise Transformer Loading								
D7	Improve Voltage Regulation								
D9	Replace Motors with High Efficiency Units								